

NACA RM E54G16



RESEARCH MEMORANDUM

THERMAL STABILITY OF PENTABORANE IN THE RANGE

329° TO 419° F

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

December 19, 1956

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SUMMARY

The thermal stability of pentaborane has been determined in the temperature range 329° to 419° F by measuring the increase with time in the formation of nonvolatile residue.

A relationship was established between the thermal stability and the temperature. The expression permitted extrapolation to obtain the stability of pentaborane at either high temperatures and short times or at ambient temperatures and long times.


INTRODUCTION

A study of the thermal stability of liquid pentaborane was undertaken at the NACA Lewis laboratory with the objective of supplying fuel-system design data. This study was aimed at obtaining knowledge of the stability of pentaborane in spray nozzles where the compound is exposed to high temperatures for short periods of time and in storage containers and fuel tanks where it is exposed to ambient temperatures for extended periods of time.

In this study, investigations were made of the amount of nonvolatile decomposition products formed when liquid pentaborane was heated for various times at temperatures from 329° to 419° F.

APPARATUS AND PROCEDURE

Apparatus. - The pentaborane was heated in a cylindrical stainless-steel bomb 5/8 inch O.D., 11/32 inch I.D., and 3 inches long. The volume was approximately 1/4 cubic inch. The bomb was closed with a 1/8-inch stainless-steel Hoke valve. The bomb was heated in an aluminum block furnace which fitted closely about the bomb. The furnace was electrically heated and suitably insulated. A thermocouple well extended through the block to the midpoint on the bomb.



Procedure. - A 1/8 cubic inch of liquid pentaborane obtained from a storage cylinder was admitted directly to the evacuated bomb. The bomb was closed, weighed, and placed in the furnace for the desired time. After removal from the furnace, the bomb was quenched and the volatile material was removed on a vacuum system until constant weight was obtained. The bomb was reweighed to determine the nonvolatile residue.

RESULTS AND DISCUSSION

Curves of the percent of nonvolatile residue plotted against time are shown in figure 1 for the five temperatures 329°, 351°, 374°, 392°, and 419° F. At 374° to 392° F the curves show a decrease in the rate of formation of nonvolatile residue with increase in time. At 419° F the curve shows that the amount of nonvolatile residue reaches a maximum of approximately 88 percent. The initial reaction may be slow in the experiments at the higher temperatures because of the time required for the bomb and pentaborane to be heated from room temperature to the reaction temperature.

Figure 2 shows a plot of reciprocal of Rankine temperature against the logarithm of $t_{20\%}-1$, where $t_{20\%}$ is the time in minutes required for the formation of 20 percent of nonvolatile residue. One minute has been subtracted from the time required for the formation of 20 percent of a nonvolatile residue in order to remove from the calculation the approximate time required to bring the sample up to reaction temperature.

These data may be represented by the equation:

$$\log(t_{20\%}-1) = \frac{1.2345 \times 10^4}{T} - 13.766$$

This plot may be extrapolated to estimate the amount of nonvolatile residue which may be expected to form when pentaborane is exposed to various temperatures. For example, if liquid pentaborane flowed through fuel lines at a temperature of 485° F, 20 percent would be converted to a nonvolatile residue in 12 seconds. In a similar manner it may be estimated that if pentaborane is stored at a temperature of 125° F, 1.6×10^4 days would be required to change 20 percent of the liquid pentaborane to a nonvolatile residue.

In these experiments liquid pentaborane was used directly from the storage cylinder in which it had been stored at room temperature for approximately 1 year. The possible effect of any impurities on these results should parallel the effect which any impurity would have on pentaborane decomposition in either fuel lines or storage tanks.

Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
Cleveland, Ohio, July 14, 1954

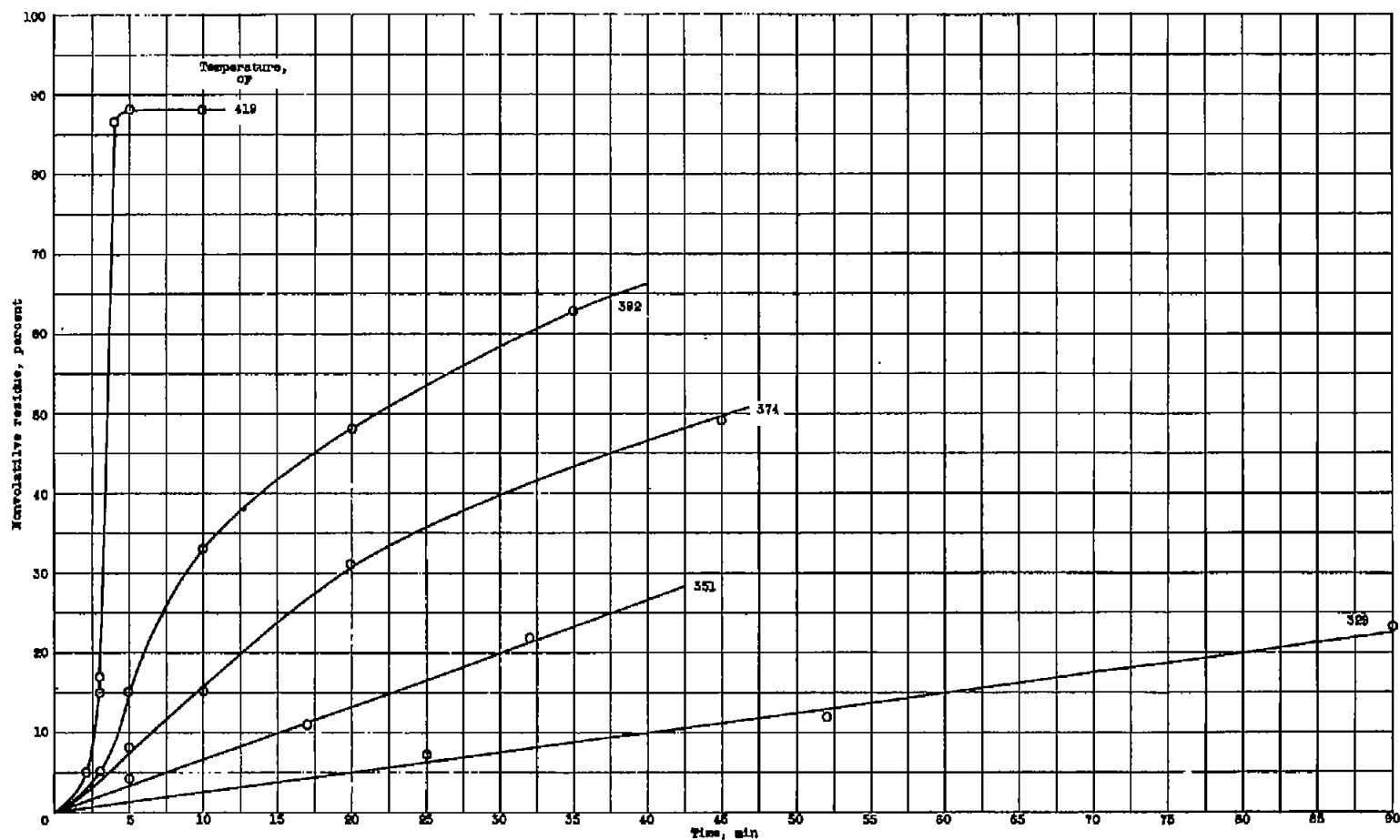


Figure 1. - Decomposition of pentaborane.

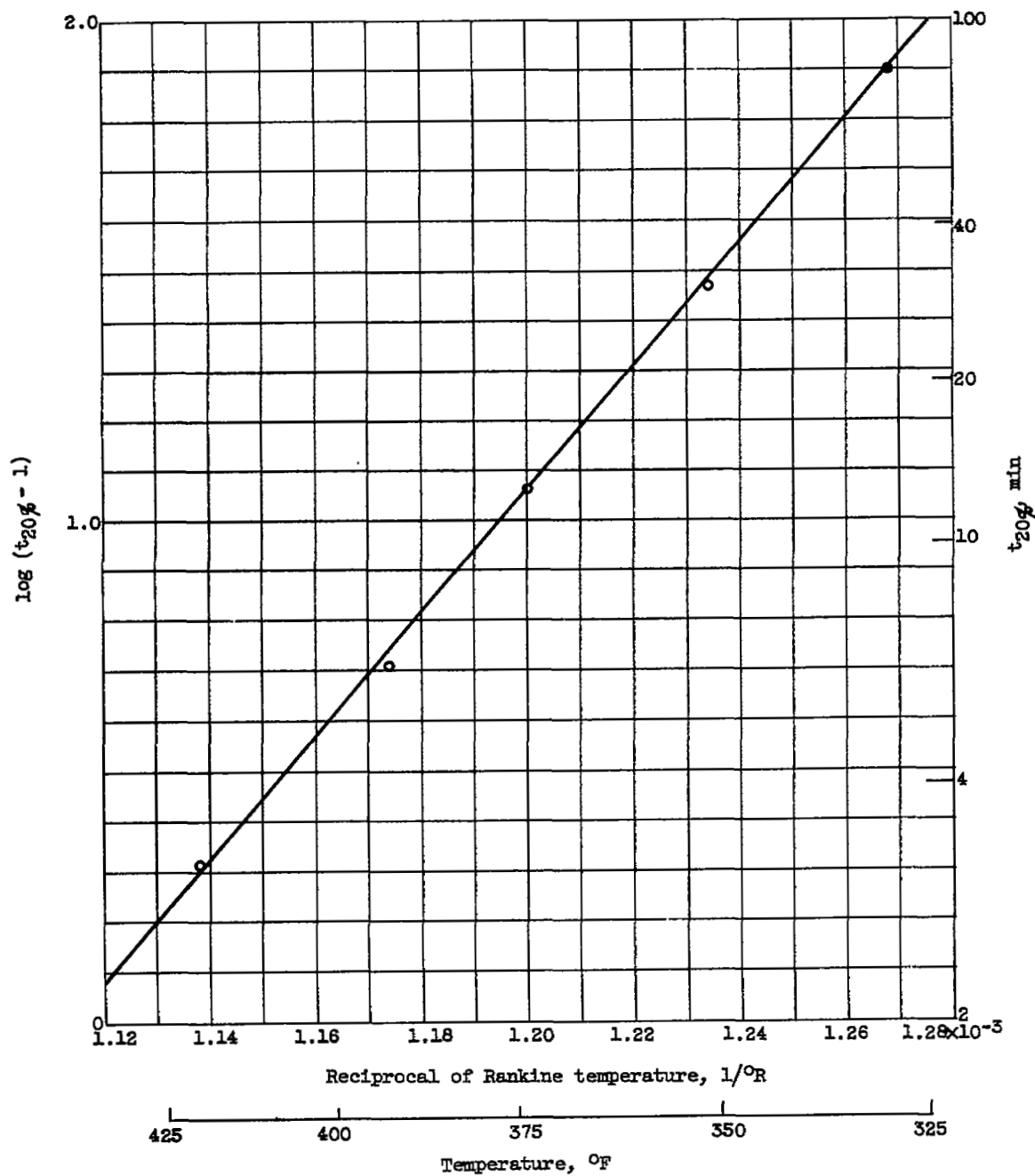


Figure 2. - Reciprocal temperature plotted against logarithm of time required for 20-percent nonvolatile residue.

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